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POSITIONING AND GUIDING DEVICE FOR THE SEALED CONNECTION OF CAPILLARY TUBES TO A MICRO-COMPONENT

[Dispositif de positionnement et de guidage pour la connexion etanche de capillaires a un micro-composant]

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Description /1*

Technical domain

The invention relates to a positioning and guiding device for the sealed connection of capillary tubes to a micro-element.

This connection technique can be used for any microfluidic component. The main applications using this type of components belong to the chemical, biological, pharmaceutical, medical domains (quantitative assay of micro-volumes, genotyping, diagnosis: DNA chips).

Prior art

In numerous microfluidics applications, it is necessary to connect fluidic micro-components (set of micro-channels, micro-reservoirs, micro-reactors, micro-valves, heating systems…) to one another or to exterior systems (reservoirs, injection systems…). A solution frequently chosen for ensuring this connection consists of the use of micro-tubes or capillary tubes. They must be inserted inside of the micro-component in order to go into a hollow structure of the channel, reservoir, reactor type… The /2 sealing is then ensured by gluing.

The capillary tubes can be inserted perpendicularly to a main surface of a component in order to be connected to channels extending parallel to this surface, in which case there exists a bend in the connection between capillary tubes and channels. The capillary tubes can also be inserted into the edge of the component as disclosed in the document "Utilizing the {111} plane switch-over etching process for micro fluid control applications" of R.E. Oosterbroek et al., Proc. of the Micro Total Analysis Systems '98, October 13-16, 1998, pages 137-140.

* [Numbers in right margin indicate pagination of the original text.]

The problem which then arises is to succeed in easily inserting a relatively large number of capillary tubes (for example, 50) in parallel into a fluidic micro-component. These capillary tubes can be independent from one another or assembled in the form of a flat sheet.

Capillary tubes made of silica glass sheathed with polyimides are ordinarily used in capillary electrophoresis (see the document WO 00/30751). Such capillary tubes, for example, those manufactured by the company Polymicro, can have an interior diameter between 2 and 500 µm and an exterior diameter between 100 and 700 µm. The company Polymicro also manufactures sheets of capillary tubes but clearly not for micro-fluidics applications.

Adhesive is ordinarily used for ensuring a sealed connection. On this subject, it is possible to refer to the article "Novel interconnection and channel technologies for microfluidics" of N.J. Mourlas et al., /3 Proc. of the Micro Total Analysis Systems '98, October 13-16, 1998, pages 27-30.

It is therefore not easy to insert a set of capillary tubes into a micro-component, regardless of whether they are interdependent from one another or grouped in sheet form.

It can be advantageous for this insertion to be done through the edge of the micro-components in order to ensure a positioning of the capillary tubes in the extension of micro-component channels. This type of connection makes it possible to avoid bends in the fluidic circuit, and the fluid injection is improved. Furthermore, it facilitates the overall architecture of the application, and a gain of space is obtained on the micro-component.

Disclosure of the invention

The present invention makes it possible to contribute a solution to the problem which arises by proposing positioning and guiding of the capillary tubes, arranged in the form of sheets or not, enabling

them to penetrate easily into the functionalized micro-component. Regardless of the function of the micro-component, the proposed solution combines with it.

This solution is completely suitable for a connection in the edge of flat micro-components (silicon chips, for example).

Since the guiding of the capillary tubes can be completely integrated in the micro-component, it is possible to connect capillary tubes with very small spacings, typically assembled with a spacing of /4 around 100 micrometers.

A first object of the invention consists of a device for positioning and guiding of capillary tubes for the connection of their first ends to a micro-component, the device having channels, each channel being suitable in shape and size for receiving a capillary tube and guiding it towards the site reserved for it in the micro-component, the device having a receiving zone for the first ends of the capillary tubes, this receiving zone exposing the first ends of the channels over a determined length and allowing positioning of the first ends of the capillary tubes in the bottom of the first ends of the channels.

The device can have a first substrate which has grooves on one of its surfaces and a second substrate connected with said surface of the first substrate in such a way as to cover the grooves with the exception of a zone of said surface of the first substrate constituting said receiving zone, the grooves thus constituting said channels.

According to an execution variant, the device can have a first substrate, which has grooves on one of its surfaces and a second substrate which, on one of its surfaces, has grooves which match the grooves of the first substrate, the first substrate being connected with the second substrate in such a way that the matching grooves are superposed in order to constitute said channels, with the exception of the zone of /5 said surface of the first substrate constituting said receiving zone.

The grooves can be V-shaped or U-shaped.

The device can be produced out of silicon or plastic. It can in particular constitute a part of a micro-component or can be associated with it.

A second object of the invention consists of a process for production of a device for positioning and guiding of capillary tubes, which includes the following steps:

- formation of grooves on a surface of a first substrate, each groove being suitable in shape and size for receiving and guiding a capillary tube,

- possibly, formation of grooves on a surface of a second substrate, which match the grooves of the first substrate,

- putting said surface of the first substrate in close contact with said surface of the second substrate, possibly with superposing of the matching grooves, in order to obtain guiding channels for the capillary tubes, with the exception of a zone of said surface of the first substrate, this zone serving as receiving zone for first ends of the capillary tubes.

The groove formation steps can consist of forming V-shaped or U-shaped grooves. These grooves can be formed by etching. If the substrate to be etched is made of silicon, the grooves can be formed by chemical etching in order to obtain V-shaped grooves. The grooves can be formed by plasma etching in /6
order to obtain U-shaped grooves.

The second substrate can have a recess corresponding to said receiving zone so that when the second substrate is put in close contact with said surface of the first substrate, said receiving zone is thus formed. Possibly, since the recess of the second substrate leaves a part overhanging the receiving zone after the second substrate is put in close contact on said surface of the first substrate, this overhanging part is eliminated. Elimination of the overhanging part can be obtained by a method chosen from cutting and cleaving.

Advantageously, the first substrate and/or the second substrate are substrates treated for constituting a micro-component.

A third object of the invention relates to a process for positioning and guiding of capillary tubes for the connection of their first ends to a micro-component, using a device which has channels, each channel being suitable in shape and size for receiving a capillary tube and guiding it towards the site reserved for it in the micro-component, the device having a receiving zone exposing the first ends of the channels over a determined length, the process including the following steps:

- positioning of the first ends of the capillary tubes facing the receiving zone, each capillary tube being placed facing the channel assigned to it, /7

- translation of the capillary tubes with respect to the device in order to put the first ends of the capillary tubes in the corresponding first ends of the channels,

- translation of the capillary tubes with respect to the device in order to make the capillary tubes penetrate into the device up to the site reserved for them in the micro-component,

- positioning of sealing means on the receiving zone in order to ensure the sealing between the capillary tubes and the device.

Brief description of the figures

The invention will be better understood and other advantages and particularities will appear upon reading of the following description given as a non-limiting example, accompanied by the appended drawings among which:

- Figures 1A to 1D describe the positioning and guiding of capillary tubes assembled in the form of a sheet, by means of a device according to the present invention,

- Figure 2 is a view in longitudinal section showing a capillary tube positioned in a micro-component thanks to a device according to the invention associated with this micro-component,

- Figure 3 shows a device according to the invention during the production process.

Detailed description of embodiments of the invention /8

The rest of the description will relate to devices in which the channels for positioning and guiding of the capillary tubes consist only of grooves made on one surface of a substrate.

Figures 1A to 1D show device 1 for positioning and guiding of capillary tubes. This device is in fact associated with a micro-component in order to form one unit. Device 1 is formed using first substrate 2 and second substrate 3. An example of manufacturing of this device will be given further on.

Substrate 2, on its upper surface, has grooves 4 of triangular cross section making the insertion of capillary tubes possible. Substrate 3 is connected with the upper surface of substrate 2 and covers grooves 4 with the exception of zone 5 called the receiving zone for the capillary tubes.

In the example represented by Figures 1A to 1D, capillary tubes 6 are assembled in the form of a sheet by holding element 7. The size of grooves 4 is provided for receiving capillary tubes 6 without their protruding beyond them. The triangular cross section of the grooves makes precise axial positioning of the capillary tubes possible.

As shown by Figure 1A, the ends of capillary tubes 6 are first placed over receiving zone 5, facing their respective grooves 4. By vertical translation, the ends of capillary tubes 6 are then put in grooves 4 /9 of receiving zone 5.

By horizontal translation, capillary tubes 6 are then made to penetrate into device 1 by sliding in grooves 4. This is what is shown in Figure 1B.

Translation of the sheet of capillary tubes is continued until holding element 7 stops against substrate 2 of device 1. This is what is shown by Figure 1C.

As shown by Figure 1D, a bead of adhesive 8 is deposited over receiving zone 5, in the corner formed by the assembly of substrates 2 and 3 of device 1. The adhesive used must be fluid enough to ensure the sealing between the capillary tubes and the grooves. The adhesive penetrates into the device by capillary action, thus occupying all the possible leakage spaces.

The cross section of Figure 2 shows the manner in which adhesive 8 occupies the space between capillary tube 6 and device 1. In this position, the end of capillary tube 6 has reached the zone corresponding to the micro-component. In order to prevent the adhesive from advancing up to the end of the capillary tube and plugging it, it is possible to vary the following two parameters. A first parameter consists of the length of penetration of the capillary tubes into the micro-component: the farther [in] the end of the capillary tube is, the smaller the risk of plugging. A second parameter consists of the viscosity /10
of the adhesive: the more viscous the adhesive is, the less it can migrate inside of the micro-component. These two parameters nevertheless have to be optimized as a function of the diameter of the capillary tube and of the cross section of the groove, in order to limit the dead spaces.

The production of the positioning and guiding device according to the invention depends on the application in which it is inserted. The device can be produced by a silicon technology or by a plastic technology.

The silicon technology uses two silicon substrates which are etched. Figure 3 represents substrates 2 and 3 which are etched and connected by gluing.

Silicon substrate 2 undergoes anisotropic chemical etching using potassium hydroxide KOH in order to obtain grooves 4 with a triangular cross section. Plasma etching would enable one to obtain grooves with a U-shaped cross section.

Substrate 3, also made of silicon, is etched in order to obtain, on one of its ends, recess 9 corresponding to receiving zone 5. Substrate 3 therefore has part 10 overhanging receiving zone 5.

Substrates 2 and 3 can have undergone other treatments relating to the production of the micro-component. They are adhered as shown by Figure 3, for example, by a molecular adhesion technique. Overhanging part 10 can then be cut or cleaved in order to expose receiving zone 5. /11

As an example, substrates 2 and 3 can be silicon plates 450 µm thick. Grooves 4 can have a width of 600 µm and a depth of 424 µm. The spacing between the grooves can be 700 µm. The length (in the direction of the grooves) of the receiving zone can be 2 mm. The length of penetration of the capillary tubes into the micro-component can be 500 µm. Such a device makes it possible to receive capillary tubes with an exterior diameter of 360 µm and an interior diameter of 164 µm. The adhesive which is used can be an ultraviolet hardening adhesive.

The plastic technology also makes it possible to produce devices of microscopic dimensions (channels of a few hundred micrometers) by molding, machining, embossing…

Claims /12

1. A device (1) for positioning and guiding of capillary tubes (6) for the connection of their first ends to a micro-component, the device having channels (4), each channel being suitable in shape and size for receiving a capillary tube and guiding it towards the site reserved for it in the micro-component, the device having receiving zone (5) for the first ends of capillary tubes (6), this receiving zone exposing the first ends of the channels over a determined length and allowing positioning of the first ends of the capillary tubes in the bottom of the first ends of the channels.

2. A device according to Claim 1, characterized by the fact that it has first substrate (2) which has grooves on one of its surfaces and second substrate (3) connected with said surface of the first substrate

in such a way as to cover the grooves with the exception of a zone of said surface of the first substrate constituting said receiving zone (5), the grooves thus constituting said channels.

3. A device according to Claim 1, characterized by the fact that it has a first substrate which has grooves on one of its surfaces and a second substrate which, on one of its surfaces, has grooves which match the grooves of the first substrate, the first substrate being connected with the second substrate in /13
such a way that the matching grooves are superposed in order to constitute said channels, with the exception of the zone of said surface of the first substrate constituting said receiving zone.

4. A device according to either of Claims 2 and 3, characterized by the fact that the grooves are V-shaped or U-shaped.

5. A device according to Claim 1, characterized by the fact that it is made of silicon or plastic.

6. A device according to any one of Claims 1-5, characterized by the fact that it constitutes a part of a micro-component.

7. A process for production of device (1) for positioning and guiding of capillary tubes (6), which includes the following steps:

- formation of grooves (4) on a surface of first substrate (2), each groove being suitable in shape and size for receiving and guiding capillary tube (6),

- possibly, formation of grooves on a surface of a second substrate, which match the grooves of the first substrate,

- putting said surface of first substrate (2) in close contact with said surface of second substrate (3), possibly with superposing of the matching grooves, in order to obtain guiding channels for the capillary /14
tubes, with the exception of a zone of said surface of the first substrate, this zone serving as receiving zone (5) for first ends of the capillary tubes.

8. A process according to Claim 7, characterized by the fact that the steps for formation of grooves (4) consist of forming V-shaped or U-shaped grooves..

9. A process according to Claim 7, characterized by the fact that grooves (4) are formed by etching.

10. A process according to Claim 9, characterized by the fact that, with substrate (2) to be etched made of silicon, grooves (4) are formed by chemical etching in order to obtain V-shaped grooves.

11. A process according to Claim 9, characterized by the fact that grooves (4) are formed by plasma etching in order to obtain U-shaped grooves.

12. A process according to any one of Claims 7-11, characterized by the fact that second substrate (3) has recess (9) corresponding to said receiving zone (5) so that when second substrate (3) is put in close contact with said surface of first substrate (2), said receiving zone (5) is thus formed.

13. A process according to Claim 12, characterized by the fact that, since recess (9) of second substrate (3) leaves part (10) overhanging receiving zone (5) after second substrate (3) is put in close contact on said surface of first substrate (2), this overhanging part (10) is eliminated. /15

14. A process according to Claim 13, characterized by the fact that the elimination of overhanging part (10) is obtained by a method chosen from cutting and cleaving.

15. A process according to any one of Claims 7-14, characterized by the fact that first substrate (2) and/or second substrate (3) are substrates treated for constituting a micro-component.

16. A process for positioning and guiding of capillary tubes (6) for the connection of their first ends to a micro-component, using device (1) which has channels (4), each channel being suitable in shape and size for receiving capillary tube (6) and guiding it towards the site reserved for it in the micro-component, device (1) having receiving zone (5) exposing the first ends of channels (4) over a determined length, the process including the following steps:

- positioning of the first ends of capillary tubes (6) facing receiving zone (5), each capillary tube (6) /16
being placed facing the channel (4) assigned to it,

- translation of capillary tubes (6) with respect to device (1) in order to put the first ends of the capillary tubes in the corresponding first ends of the channels,

- translation of capillary tubes (6) with respect to device (1) in order to make the capillary tubes penetrate into the device up to the site reserved for them in the micro-component,

- positioning of sealing means (8) on receiving zone (5) in order to ensure the sealing between capillary tubes (6) and device (1).

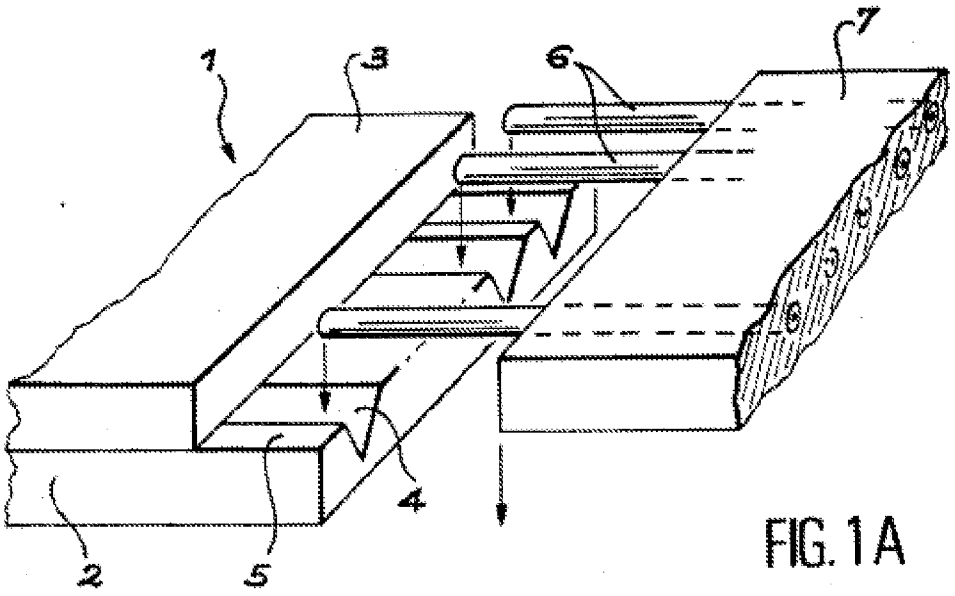

FIG. 1A

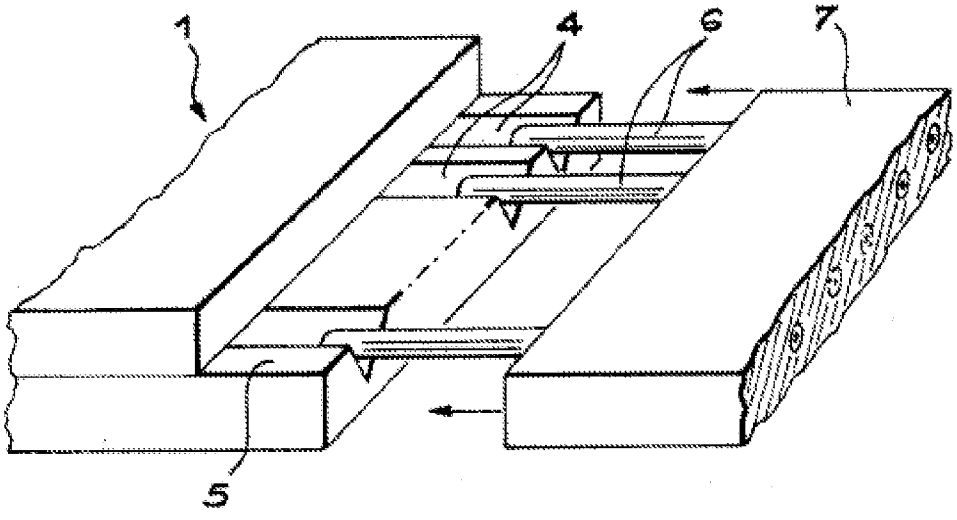

FIG. 1B

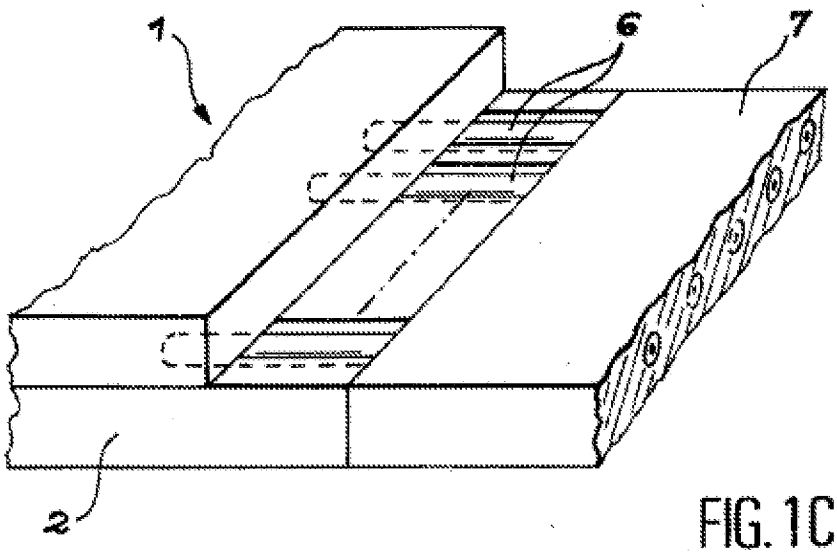

FIG. 1C

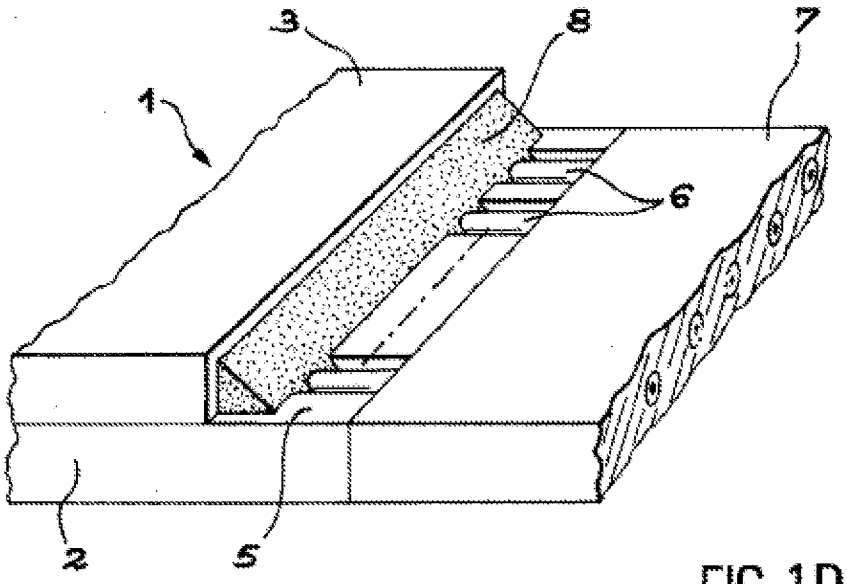

FIG. 1D

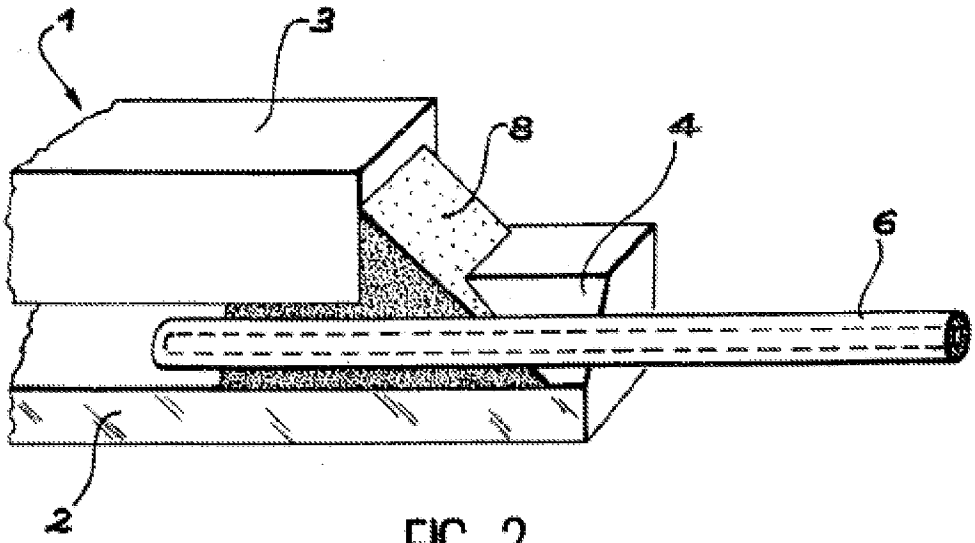

FIG. 2

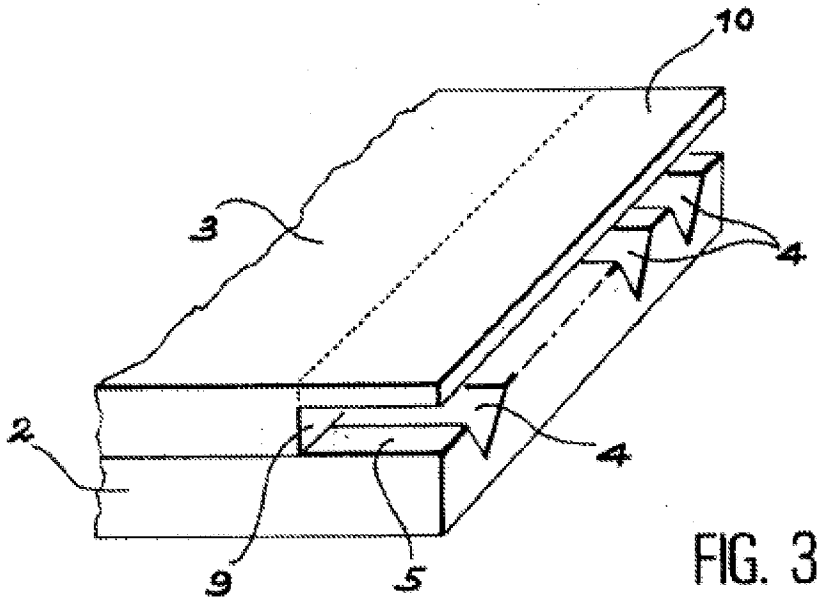

FIG. 3

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PRELIMINARY SEARCH REPORT

established on the basis of the most recent claims
filed before the start of the search

DOCUMENTS CONSIDERED TO BE RELEVANT		Claims concerned	Class attributed to the invention by INPI
Category	Citation of document with indication where appropriate, of relevant passages		
X	WO 98 25065 A (DODGSON JOHN ROBERT; SHAW JOHN EDWARD ANDREW (GB); TURNER CHRIS (G) June 11, 1998 (1998-06-11) * abstract; figures 1-6 * * page 3, line 28 – page 4, line 11 * * page 4, line 35 – page 5, line 35 * * page 7, line 10 – page 7, line 34 *	1-11, 15, 16	B81C3/00 B81B1/00
A	---	12-14	
A	US 5 890 745 A (KOVACS GREGORY T A) April 6, 1999 (1999-04-06) * abstract; figures 1,2 * * column 1, line 4 – column 2, line 14 *	1-16	
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A	GONZALEZ C ET AL: "Fluidic interconnects for modular assembly of chemical Microsystems" SENSORS AND ACTUATORS B, ELSEVIER SEQUOIA S.A., LAUSANNE, CH, vol. 49, no. 1-2, June 25, 1998 (1998-06-25), pages 40-45, XP004141435 ISSN: 0925-4005	1-16	B01L F15C

A	GRAY B L ET AL: "Novel interconnection technologies for integrated microfluidic systems" SENSORS AND ACTUATORS A, ELSEVIER SEQUOIA S.A., LAUSANNE, CH, vol. 77, no. 1, September 28, 1999 (1999-09-28), pages 57-65, XP004244547 ISSN: 0924-4247 * the whole document *	1-16	

Date of completion of the search	Examiner
October 1, 2001	Runser, C

CATEGORY OF CITED DOCUMENTS
X: Particularly relevant if taken alone.
Y: Particularly relevant if combined with another document of the same category.
A: Technological background.
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